INEL

Idaho National Engineering Laboratory

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Project/Task: OU 7 13/14 Feasibility Study
Subtask: Surface Barriers

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TITLE: Digest # 2 of Reports on Surface Barriers for Arid Regions

SUMMARY

The summary briefly defines the problem or activity to be addressed in the EDF, gives a summary of the activities performed in addressing the problem and states the conclusions, recommendations, or results arrived at from this task.

This EDF contains notes from reading four documents regarding caps. The four documents are:

1. Anderson J.E., Nowak R.S., Ratzlaff T. D., Markham O.D., Managing Soil Moisture on Waste Burial Sites in Arid Regions, J.Environ. Qual. 22:62-69 (1993)

2. Gee, G.W., Wing N.R., In-Situ Remediation: Scientific Basis for Current and Future Technologies, Thirty-Third Hanford Symposium on Health and theEenvironment, Nov 7-11,1994, "Surface Bariers: Problems, Solutions, and Future Need" Daniel, D.E. p441

3. Anderson J.E., Limbach W.E., Ratzlaff T.D., Protective Cap/Biobarrier Experiment II: A Comparison of Water Use by Annual and Perennial Species on Simulated Waste Burial Plots at the INEL

4. Keck J.F., Evaluation of Engineered Barriers for Closure Cover of the RWMC SDA, EDF RWMC-523 January 1992

Distribution (complete package): C.M. Barnes, C. Shapiro, R. Huntley, D. Jorgensen

Distribution (summary page only):

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Digest of Reports #2

1.) Managing Soil Moisture on Waste Burial Sites in Arid Regions

A field study was done at the INEL to determine the correct soil depth needed on the top layer of a waste cap. Ten simulated waste trenches were established on level sites during the fall of 1983. Each 3 x 10.7 m trench was excavated to a depth of 2.4 m and then filled with the soil that is used for capping trenches at the INEL SDA. The soil consisted of 26% sand, 54% silt, and 20% clay. As the trench was filled the soil was compacted. Of the ten plots, two were left unplanted and treated with an herbicide to prevent the growth of plants. The remaining eight plots were planted with four species of plants, two plots each. From 1984 through 1986 the soil water content on all of the plots were monitored under natural precipitation. In 1987 and 1988 one plot of each species was irrigated to simulate a wet year. These plots received 366 mm of water.

The results showed that all four species can remove water from a waste trench cap to a depth of at least 2.2 m and they indicate that any of the species could use all of the water that might be stored in the soil during a very wet year. Relatively little water was lost from the bare plots. The data showed that bare soils may quickly reach the drained upper limit, and the influx of water from normal precipitation likely will result in deep drainage. It is evident that vegetation is essential to remove water from the entire soil cap and thereby empty the storage reservoir each year. A 2 m depth of soil is recommended for the INEL.

2) Surface Barriers: Problems, Solutions, and Future Needs

The problem of designing a surface barrier for a remediation project can be an enormously challenging task. There is a widely held misconception that surface barrier technology is well developed and works as expected. In fact, the technology is largely unproven and experimental, particularly in terms of a long term performance.

The primary challenges are 1) developing surface barriers that can withstand large differential settlement, 2) using materials that can withstand seasonal changes in water content without cracking 3) developing hydraulic barriers that will be essentially impermeable for hundreds of years or longer and 4) field verification that surface barriers are working as anticipated.

The geosynthetic liner (GCL) which contains a thin layer of bentonite is much more able to resist damage from freezing/thawing, desiccation, and differential settlement than compacted clay liners (CCL). Most compacted soils cannot withstand high tensile strains. The question that needs to be answered is how much tensile strain or settlement can a liner withstand before cracking? Most surface barriers placed over compressible materials undergo settlements of .5 m or larger. It is pointless to have an impermeable layer if the layer is destined to develop tension cracks.

The maximum tensile strain that a geomembrane can withstand is at least an order of magnitude greater than that for a compacted soil. It is also not vulnerable to damage from desiccation or freeze-thaw. Geomembranes may not provide long enough protection for some radioactive wastes. However their low cost and high degree of effectiveness for at least several hundred years make geomembranes potentially viable materials even if only for redundancy. The GCL liner is also able to withstand large distortion and tensile strain. It is a combination of the geomembrane and CCL because it has a layer of bentonite. There is a lack of data on how much differential settlement that surface barriers can withstand before their ability to limit infiltration is compromised.

The approach toward subsidence appears to assume that subsidence will occur in the waste and sink holes will appear in the surface cap. Cracks in the top layer are to be expected. The focus is on having an impermeable layer that can withstand the tensile strain without cracking. The GCL's appear to be meeting this criteria while compacted clay or compacted soil liners are not but more data is needed.

The EPA cover design calls for an "engineered barrier". The geomembrane/compacted soil layer is called for in EPA (RCRA) cover designs. This cover design is also called for in remediation projects regulated under EPA's Superfund program (CERCLA). If a GCL is to be used it must meet or exceed the stated or implied performance objectives for the compacted soil liner.
The RCRA cover design is meant for the 30 year closure period though it should last much longer. The design is not meant for 1000 years. Natural processes such as capillary breaks need to be used to limit percolation of water through the barrier instead of geomembranes, and GCL's if the barrier is to last over 1000 years.
The RCRA cap is not a technology that has been proved to work well. The solutions are to make greater use of natural processes for control of erosion and infiltration of water and to use alternative barrier materials.

3.) Protective Cap/Biobarrier Experiment II: A comparison of water use by annual and perennial species on simulated waste burial plots at the INEL.

Plants in arid regions, such as the INEL use all the available soil water during a growing season because potential evapotranspiration far exceeds precipitation. A cover of perennial vegetation can be used effectively to preclude drainage through soil caps. However cheat grass and other exotic annuals have replaced native perennial species in many sagebrush steppes in the Intermountain West. Annuals may not extract all of the soil moisture during a growing season. The data from tests done in 1993 and 1994 suggest that the likely result of the replacement of perennial species by annuals on a soil cap would be drainage of water through the protective cap and into the waste zone.

4.) Evaluation of Engineered Barriers for Closure Cover of the RWMC SDA
This EDF covers much of the same ground as report #2. In establishing the performance objectives for the entire SDA the EDF states that while only EPA (RCRA) and DOE requirements are necessary the EPA-NRC guideline is a good model because of the requirement for 100 years up to 500 years of effectiveness. The closure covers that are recommended by the EDF do meet these longer goals though it is not required by the DOE performance assessment.

Subsidence and permitting are major technical issues. The EDF does use the data from the 1984 to 1988 testing . Other sources of field data are cited to support the choice of cover designs including the hydrologic models that have been completed. Other models were run for the reduction of exposure for the intruder-agriculture, intruder-construction, and the intruder-drilling scenarios. Maximum exposure reduction for intruder-agriculture is reached at a cover thickness of 3 m and additional cover thickness provides no additional exposure reduction. For the intruder-construction scenario the maximum cover thickness is from 3 m to 6m. Cover thickness does not reduce exposure for the intruder-drilling scenario.

The issue of maintaining a vegetative cover is again raised by citing data that crested wheat grass is estimated to be resistant to invasion by native plant species for 30-50 years without active maintenance This would likely be displaced by sagebrush and grass over time.

The SDA soils are "slightly to moderately" susceptible to subsidence. Long term settlements might range up to 2 ft due to the collapse of soil bridges and waste containers.

An adaption of the CERCLA process for identification and screening of remedial alternatives was used to formulate preliminary closure cover conceptual design alternatives. The CERCLA process identifies general response actions; identifies and screens a range of technology types representative of each general response action; and combines favored technology types into alternatives which are subjected to more detailed analysis.
Five SDA closure cover design alternatives were identified:

1. An evapotranspiration storage cover with a capillary /biobarrier
2. A thin soil only ET storage cover
3. A thick soil only ET storage cover
4. A RCRA 3 layer cover
5. A concrete sealed surface cover

Field scale testing of concrete barriers is not recommended due to the very high expected cost of closure of large scale areas.

A vegetated surface is recommended for use on all four designs. Use of a gravel mulch topsoil has been found to promote vegetation growth and reduce surface wind and water erosion.
The gravel - cobble combination of the first alternative provides both biointrusion protection and a capillary barrier function. The use of geotextiles is recommended to maintain a distinct capillary gradient. The biobarrier also provides a higher degree of human intruder protection than a soil only layer of equivalent thickness.

The thin soil design does not provide significant protection from intrusion by plants and burrowing animal, nor maximum long - term intruder radiological exposure protection. Short-term effectiveness is therefore good, while long-term effectiveness is estimated to be poor.

The thick soil cover (5 m - NRC guidance) provides better long-term effectiveness for reduction of inadvertent intruder exposure and biointrusion by plants and burrowing animals. Infiltration control for this design is not significantly better than for the thin soil cover and is probably less effective than the capillary barrier design.

The RCRA cover does not produce significantly better short term infiltration control than that which may be afforded by the first design as determined by using the EPA recommended HELP code model. The possibility for holes in the low permeability layer is high. The leakage factor increases with time as subsidence produces seam rips and other tears.

5.0 Feasibility Study

The design alternative of using a surface barrier for the SDA will be able to use the data from the set of testing ongoing at the RWMC. This data will not be available until 1998-1999. If a recommendation is actually needed in 1996 it will be that the technology is not yet proven because of a lack of data on how the cap will last 1000 years and the amount of infiltration when the vegetation is destroyed. Data from Hanford might be forthcoming that could answer these issues. Discussions and literature review will continue until March 1996.